ENERGY CONSUMPTION MANAGEMENT OF BASIC CONDENSATE PUMPS, RELATED TO TA 330 MW, FOR C.T.E ROVINARI

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Abstract: The basic condensate circuit is formed by the functional connections existing between the equipment functionally provided in the turbocharger scheme, between the capacitor and the degasser. The basic condensate pumps provide the extraction of the condensate from the condenser tank, its circulation through different heat exchangers maintaining the level in the supply water tank (degasser). The actual energy balance is drawn up as a time balance.

Key words: energy, condensate pumps, circuit

1. INTRODUCTION

The basic condensate is also passed through the condensate treatment station, in order to retain the oxides and salts escaped with the eventual infiltration of cooling water into the condenser; Since the allowable pressure for the filters of the condensate treatment station is 6kgf/cm^2, a two-stage basic condensation pumping scheme has been adapted.The stage I condensate pump extracts the base condensate from the condenser, discharging it through a summer cooler, or its bypass, to the hydrogen coolers, the stator windings of the generator and, in parallel, to the sealing steam condenser.

Next, the condensate is conveyed through the condensate treatment station, where its chemical treatment takes place.

The second stage basic condensate pump, connected in series with the 1st stage pump, flows back to the degasser, passing through the low pressure preheaters, or in recirculation to the condenser, or the water tank. On the suction pipe of the first stage condensate pump, an electrically actuated valve and an F filter are fitted to retain mechanical impurities.

On the discharge pipe of the first stage condensate pump, a check valve and an electrically actuated valve are installed to fill the circuit at start-up with water from the addition tank. Upstream of the filter, a suction pipe with a manual valve connected to the condenser is provided on the suction pipe. Also, on the discharge there is a ventilation pipe, with manual valve, connected to the condenser. There is also a check valve and an electrically actuated valve on the flow of the second stage basic condensate pump.

In order to avoid the low-speed operation of the second stage basic condensate pump, a recirculation circuit is provided, which directs the water to the condenser via a regulating valve.

2. ESTABLISHING THE BALANCE SHEET OUTLINE

For the calculation of the energy balance of the basic condensate pumps, related to TA 330 MW, we consider the simplified scheme of Fig.1

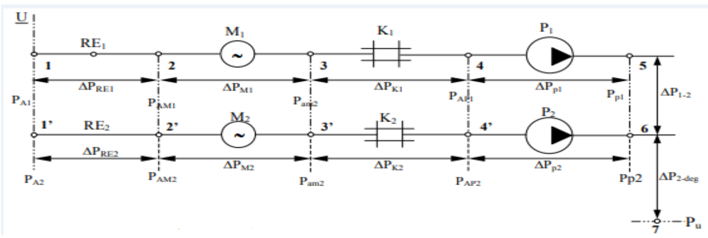

Figura 1. Basic condensate pump installation diagram

The outline of the balance sheet passes through points 1-5, 1-6, 5-6-7.

The equations of the hourly energy balance in this outline are the following:

$P_{A1} = \Delta P_{RE1} + \Delta P_{M1} + \Delta P_{k1} + \Delta P_{p1} + P_U$

$P_{A2} = \Delta P_{RE2} + \Delta P_{M2} + \Delta P_{k2} + \Delta P_{p2} + P_{U2}$

$P_{U1} + P_{U2} = \Delta P_{1\text{-}2} + \Delta P_{ref} + P$

In order to prepare the balance sheet, the measurements in table 1 were determined by measurements. Calculation of useful pumping energy.

Calculation of energy losses a) Hourly energy losses in the electrical power cord

The calculation relation is: $Q = \frac{Q_m}{\delta} \left[\frac{m^3}{s}\right]$

pr - pump discharge pressure [N / m3];

- the specific weight of the base condensate [N / m3];

The volumetric flow rates of the two pumps:

$$Q_1 = Q_2 = \frac{700.1000}{996.3600} = 0{,}195 m^3/s$$

Tasks of the two pumps:

$$H_1 = \frac{(24-4.3)\cdot 10^5}{996\cdot 9.81} = 201{,}7m$$

The useful hourly energies of the two pumps:

$$P_{U_1} = \frac{996.9{,}81.0{,}195.79{,}5}{1000} = 151{,}7kWh/h$$

$$P_{U_1} = \frac{996.9{,}81.0{,}195.201{,}7}{1000} = 384{,}6\ kWh/h$$

Table 1. Measured sizes and their values

Nr. Crt	Size	Value	UM
1.	Mass flow	700	t/h
2.	Traction suction pressure Tr. I	0,031	bar
3.	Pump discharge pressure Tr. I	7,8	bar
4.	Pump suction pressure Tr. II	4,3	bar
5.	Pump discharge pressure Tr. II	24	bar
6.	Degassing pressure	5,7	bar
7.	Supply voltage (tr. I and II)	6000	V
8.	Pump supply motor current Tr. I	34	A
9.	Power absorbed by engine feed pump Tr. I	279,1	kW
10.	Power factor of engine power supply pump Tr. I	0,74	-
11.	Equivalent ohmic resistance of the Tr. I pump feed motor	1,17	Ω
12.	Pump supply motor current Tr. II	69,7	A
13.	Power absorbed - Tr. II pump feed motor	649,9	kW
14.	Engine power supply factor Tr. II	0,84	-
15.	Equivalent ohmic resistance of the Tr. II pump feed motor	0,37	Ω
16.	Material of power cables	Aluminium	
17.	Power cord section	185	mmp
18.	Engine power supply cable length Tr. I	80	m
19	Length of motor power cable Tr. II	120	m

Calculation of energy losses

a) Hourly energy losses in the power supply cable (ΔP_{RE}) The calculation relationship is:

$\Delta P_{RE} = 3\boldsymbol{K_f^2 . I_{med}^2 . R_{el} . \tau_f . 10^{-3}[kWh/h]}$

K_f - current form factor, K_f = 1.01;

$Rel = R_0 . L_{RE}$

where

R_0 – specific resistance of the cable, R_0=0,197 Ω/km (la 70°C);

L_{RE} – cable length, [m];

R_{el_1} = 0,01576 Ω

R_{el_2} = 0,02364 Ω

Using the measured values of the current, that is I_1=34 A şi I_2=69,7 A,

the losses on the two power cables result:

ΔP_{RE1}=0,055KWh/h

ΔP_{RE2}=0,0551KWh/h

b) The hourly energy absorbed by the engine (P_{AM}) is determined by the relation:

$P_{AM} = P_A - \Delta P_{RE}$

ΔP_{ct1}=16,1 kWh/h

ΔP_{ct2}=43,3 kWh/h

The variable losses are determined by the relation:

$\Delta P_{var_i} = \Delta P_{var_n} \left(\frac{I_{mas}}{I_n}\right)$

ΔP_{var_1}=5,1 kWh/h

ΔP_{var_2}=8,02kWh/h

As a result, total energy losses in the engine:

ΔP_{M1} = 21,2 kWh/h

ΔP_{M2} = 51,32 kWh/h

Therefore, the hourly energy at the motor shaft is:

$P_{aM} = P_{AM} - \Delta P_M$

P_{aM_1} = 257,845 kWh/h

The efficiency of the two engines are:

η_{M_1}=0,92 η_{M_2}=0,92

Coupling losses are (k):

$P_{AP} = P_{aM} . \eta_k$

η_k= transmission-pump efficiency

$\boldsymbol{P_{AP_1}}$= 232,06 Kwh/h

P_{AP_2}= 580,08 Kwh/h

Coupling losses are:
ΔP_{K_1}= 25,785 kWh/h

c) Energy losses on the network between the two pumps:

$\Delta P_{1\text{-}2} = \frac{\Upsilon . Q . h_{r_{1-2}}}{1000}$ [kWh/h]

$h_{r_{1-2}} = \frac{p_{r1} - p_{a2}}{\Upsilon_{med}} - H_{s12}$ [m]

$h_{r_{1-2}}$= 30,8 m $\Delta P_{1\text{-}2}$ = 58,8 kWh/h

d) Energy losses on the network between the discharge of the Tr II pump and the degasser (including the valve adjustment:

$\Delta P_{2\text{-deg}} = \frac{\Upsilon . Q . h_{r_{2-deg}}}{1000}$ [kWh/h]

Therefore, the hourly energy at the motor shaft is: $h_{r_{2-deg}} = \frac{p_{r2} - p_{deg}}{\Upsilon_{med}} - H_{s2-deg}$ [m]

$h_{r_{2-deg}}$ = 168,3 m; $\Delta P_{2\text{-deg}}$ = 321 kWh/h

e) Energy losses in the pump (P):
- for step I pump: $\Delta P_{P_1} = P_{AP_1} - P_{U_1}$ =80,4 kWh/h
- for step II pump: $\Delta P_{P_2} = P_{AP_2} - P_{U_2}$ =195,5kWh/h

The energy losses inside a pump are distributed as in Fig. 2, where the following notations were used: P - energy absorbed Pu - useful hourly energy; Pt - theoretical hourly energy
ΔPv - hourly hydraulic losses
Ph - hydraulic hourly energy;
ηv - the volumetric efficiency of the pump.
ΔPpm - hourly mechanical losses
η - total pump efficiency.
ΔPv - hourly volume losses
η_h - hydraulic efficiency of the pump

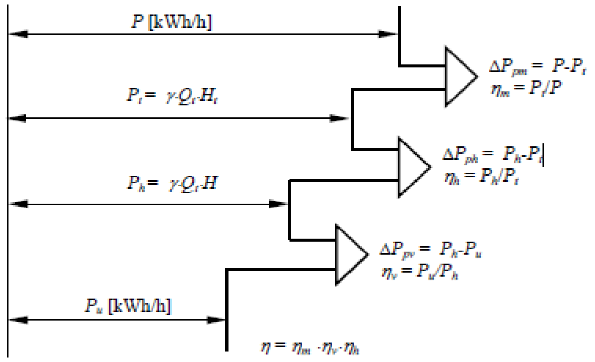

Fig. 2. *Schedule of hourly energy losses in a pump*

f) Total energy losses in the balance sheet:
$\Delta P_{pierd} = \Delta P_{RE1,2} + \Delta P_{M1,2} + \Delta P_{k1,2} + \Delta P_{1,2} + \Delta P_{1\text{-}2} + \Delta P_{2\text{-deg}}$ = 772,5 kWh/h

Calculation of total useful energy

The useful energy for the condensate pumping system assembly is the energy consumed for bringing the condensate flow from the condenser pressure to the degasser pressure and from the –5m to the + 19m dimension (a total height difference of 24 m). This energy can be calculated by the formula:

$P_u = \frac{\Upsilon . Q . h_{r_{cond-deg}}}{1000}$ [kWh/h]

$h_{r_{cond-deg}} = \frac{p_{deg} - p_{cond}}{\Upsilon_{med}} + H_{s\ cond-deg}$

p_{cond} – pressure in the condenser [N/m2]
p_{deg}– the pressure in the degreaser [N/m2]
$p_{deg} - p_{cond}$ – the difference in height between the capacitor and the degasser [m]
$h_{cond\text{-}deg}$ = 82 m
P_u = 156,4kwh/h

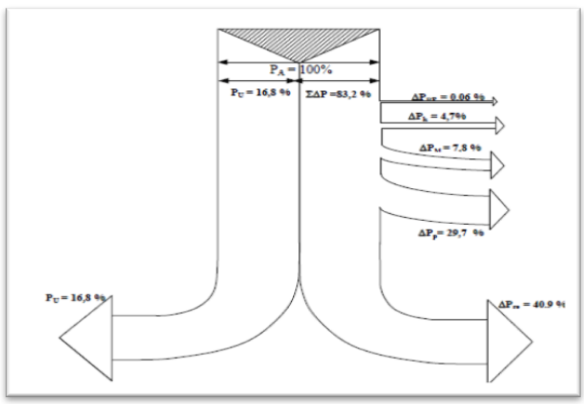

Fig. 3. Sankey diagram of the real energy balance

Calculation of energy efficiency efficiency indicators:
- net energy efficiency

$\eta_{net} = \frac{P_U}{P_A} \cdot 100 = 16.8\%$

- net specific consumption of electricity achieved:

$C_{ne/apr} = \frac{P_A}{Q} = 1,32 kWh/m^3$

3. CONCLUSIONS

Rovinari is a strong industrialized city, with a medium level of development, major accessibility and communication paths, and a relatively young population. The weaknesses are characterized by environmental problems (pollution, landscape change) and the high degree of dependence on mining and electricity production. According to H.G. 193/1999, the city of Rovinari was declared a disadvantaged area and was introduced in the special program for disadvantaged areas for a period of 10 years according to H.G. 521/2000. The Rovinari Thermal Power Plant is located "at the mouth of the mine", unique in the country, which offers the possibility of direct energy recovery of the large quantities of lignite from the quarries included in the company, ensuring a distance and minimum costs of transporting coal from the source. C.T.E. Rovinari plays a major role in the electricity market in Romania, being the second largest power station in the country.

Mining exerts a positive influence from the point of view of the economic, social and urban development of the mining areas and negative influences related to the change of the environment, with an impact on agriculture and forestry, hydrography, communication paths, decommissioned human settlements, the quality of life of the inhabitants, as well. and in the fauna and flora of the operating perimeters and those bordering on them.

Following the real oral balance of the installation of the basic condensate pumps, related to TA 330MW, it was found that:
- The efficiency of the pumps is diminished compared to those provided in the technical book, respectively 65.4% and 66.3%, compared to 78% provided.
- The efficiency of the engines is low (92%), compared to the efficiency of today's high efficiency engines, ie 97 - 98.5%.
- The overall efficiency of the basic condensate pumps installation is very low (16.8%)
- The specific electricity consumption achieved for pumping the basic condensate is very high (1.32 kWh / m^3)

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